## VI. "On the Plasticity of an Ice Crystal. (Preliminary Note.)" By JAMES C. MCCONNEL, M.A. Communicated by R. T. GLAZEBROOK, F.R.S. Received May 29, 1890.

Two years ago, in the 'Proceedings of the Royal Society,' was published an account of some experiments on the plasticity of ice made by Mr. Kidd and myself. We proved the oft-repeated statement, that glacier ice is not plastic under tension, to be erroneous, and, indeed, that an ordinary bar of ice composed of several crystals will yield continuously either to pressure or tension. But we found that a bar cut out of a single crystal with its length at right angles to the optic axis showed no signs of continuous stretching, even when subjected to half the breaking stress; and other experiments convinced us that an ice crystal will not change its shape under either tension or pressure applied at right angles to its optic axis. These results seemed to render it highly probable that an ice crystal was not in any way plastic, and though, after the winter was over, we wished that we had varied our experiments more, yet we quite expected further experiments only to have corroborated the perfect "brittleness" of a single crystal.

Last winter I resumed the experiments alone. Cutting small bars from uniform crystals, I supported their ends and hung weights halfway between the supports. The result was the discovery of a peculiar kind of plasticity in an ice crystal. The clearest idea of the nature of this plasticity is given by the following analogy:—A crystal behaves as if it were built up of an infinite number of indefinitely thin sheets of paper fastened together with some viscous substance which allows them to slide over each other with considerable difficulty; the sheets are perfectly inextensible and perfectly flexible. Initially, they are plane and perpendicular to the optic axis; and when by the sliding action they become bent, the optic axis at any point is still normal to the sheet at that point. Thus, when a bar with the optic axis transverse to its length is placed so that the axis is horizontal, and the sheets of paper consequently vertical and longitudinal, it refuses to take any plastic bend, however long the weight be applied. If the bar be now turned over, so that the sheets of paper are horizontal, quite a short interval suffices to produce a decided permanent depression of the middle of the bar. In such a case, long narrow bubbles in the ice originally vertical remain vertical, but the optic axis bends with the bar, so that in one half of the bar it is inclined to its position in the other half. The sides of the bubbles were unbroken by steps or "faults," showing that the sliding did not take place at a limited number of surfaces, but was an all-

pervading molecular effect. This conception fully explains our results of two years ago that bars of ice with the axis transverse yield neither to pull nor thrust. If we had tried a bar with the optic axis oblique, it would have stretched readily enough.

The rate of distortion was very irregular, showing a strong tendency to increase with the length of time for which the weight was applied. When extra weight was put on, the rate increased more than in proportion to the weight itself, but less than in proportion to its square. The effect of temperature was generally masked by these others, but there could be no doubt of its existence; the rate at $-2°$ being in one case twice or three times as great as *cæteris paribus* at $-10°$.

Plasticity, due to sliding planes (Gleitflächen), has been shown to exist in rock salt, Iceland spar, &c., by Reusch and others. In rock salt these planes are parallel to the faces of the rhombic dodecahedron, and in general there are several different sets. As long ago as 1867, Reusch suggested their existence in ice as a means of explaining the observed plasticity. I find that the observation that an ice crystal is plastic was made by Hagenbach in 1881, but he did not further investigate the matter.

## VII. "Preliminary Note on a New Magnetometer." By W. Stroud, D.Sc., Professor of Physics, Yorkshire College, Leeds. Communicated by Professor A. W. Rücker, F.R.S. Received May 30, 1890.

The determination of the horizontal component of the earth's magnetic field is of great importance, not only for the purpose of magnetic surveys, but also for the determination of the absolute strength of an electrical current, a measurement frequently required, not only for scientific work of various kinds, but also for the calibration of ammeters and voltmeters, and other electrical measuring instruments.

The usual method of measuring this important quantity is that of Gauss, but the method is so long and laborious, and the apparatus requisite for accurate determination so expensive, that the measurement of H is avoided whenever practicable. The writer, having devised an instrument capable of determining H with great expedition and accuracy, ventures to think that a description of the instrument may not be without interest.

Gauss's method consists, as is well known, in finding (1) the deflection produced upon a small magnetic needle by a large magnet of moment M, placed at a known distance from, and in a certain position with regard to, the needle; and (2) the time of vibration of the deflecting magnet when suspended so as to oscillate in a horizontal